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Soft d in Danish: Acoustic characteristics and issues in transcription

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Abstract. Danish, like closely related Swedish and Norwegian, has descended from Old Norse (Haugen 1976). While the three contemporary languages are variably mutually intelligible, Danish has phonologically diverged from the other Scandinavian languages (Gooskens 2006). This is caused by extensive consonant lenition and vowel reduction within Danish (Basbøll 2005). The lenition of <t> and <d> in syllable coda positions into a sound that Danish linguists have called soft d is seemingly unique to the Danish. In most phonological descriptions, it is transcribed using the phonetic symbol /ð/, a voiced interdental fricative. We assert that this is not accurate; not all phonologists agree that the soft d is a fricative. Some describe it as an alveolar semi-vowel (Haberland 1994), while others transcribe it as a velarized, retracted, and lowered alveolar approximant (Basbøll 2005). Many observe that the sound resembles lateral /l/, a distinct phoneme of Danish (Wells, 2010). Through acoustic analysis of tokens taken from the DanPASS corpus (Grønnum 2016) we show that the acoustic properties (HNR) of soft d are indeed not the same as a fricative, but rather that of an approximant or vowel. Therefore, the use of /ð/ to transcribe this symbol is inaccurate and does not align with the goals of the International Phonetic Association.

Keywords. phonetics; transcription; international phonetic alphabet; Danish; lenition

1. Introduction. 1.1 DANISH AND SOFT D. Danish is a Germanic language spoken in Denmark. One of the Scandinavian languages, it is descended from Old Norse and its sister languages include Norwegian, Swedish, Icelandic, and Faroese. The Scandinavian languages are split into two groups: insular (e.g., Icelandic and Faroese) and continental (e.g., Danish, Norwegian, and Swedish). In modern times, the level of mutual intelligibility between the languages varies, with the continental languages retaining a relatively high level of mutual intelligibility that has been diminished compared to the insular languages (Gooskens 2006).

The mutual intelligibility between Norwegian, Swedish, and Danish has been shown to be asymmetrical. Namely, speakers of Danish have a much easier time understanding spoken Norwegian and Swedish than vice versa (Schüppert 2011). The difficulty of understanding Danish is attributed to a variety of both linguistic and extralinguistic factors. The linguistic factors include numerous phonological changes that the language has undergone in the past couple of centuries that have caused it to drift from its sisters to the north: (1) vowel reduction, (2) adoption of a uvular <r> pronunciation, and (3) lenition of <t> and <d> (von Ommen et al. 2013; Goblirsch 2014). In the case of vowel reduction, most of the time, low [a] reduces to either [ɛ] or [ə]. The adoption of uvular [ʁ], or *skarre-r* in Danish, is thought to be due to its proximity to Germany and borrowing the sound from German. These two, coupled with the lenition of <t> and <d> cause words such as *hader* (hate) to be transcribed as [hɛðʁ̩] (Grønnum 1998).

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The focus of this paper is point (3) from above: the lenition of <t> and <d> into what has been called soft d. This sound has been described as being unique to the Danish language and has been a topic of both discussion and disagreement among Danish linguists. Descriptions from Danish linguists vary from a voiced interdental fricative to an alveolar semi-vowel (Haberland 1994), alveopalatal approximant (Grønnum 1998), and a velarized, retracted, lowered alveolar approximant (Basbøll 2005). These variations in descriptions put forward by linguists are also mirrored in the way that they choose to transcribe the sound. While the convention in place is to transcribe words containing soft d with /ð/, other linguists have chosen to embellish this symbol with a variety of diacritics in an attempt to modify a simple voiced interdental fricative into something more attuned to their approximant- or semi-vowel-like descriptions. Popular modified versions of /ð/ include: [ð̞ʲ] and [ð̠].

Native-speaker intuition is also full of its own variation. When asking native Danish speakers how they make the sound, there are descriptions ranging from "basically an /l/, but with the tongue behind the bottom teeth" to "I have no idea." Among linguists and non-linguists there is also often a sense that the sound is "/l/-like" (Gooskens 2006; Nordvig 2018); this sense of soft d being lateral or /l/-like has also been expressed by British linguist John Wells (2010).

1.2. PLOSIVE LENITION. Danish is not the only language to have spirantized /d/. A well-studied example of this phenomenon is the lenition of intervocalic /d/ in Spanish and other Iberian languages. While acoustic and articulatory evidence indicates that /d/ is lenited to an approximant in these contexts (Simonet et al. 2012), linguistic descriptions typically transcribe it as [ð]. The lenition of /d/ in Spanish is part of a larger pattern of stop lenition within the language, where /b/ and /g/ are also lenited to approximants intervocally. Like with /d/, these allophones are also transcribed as fricatives (Hualde et al. 2011) to coincide with traditional narratives of this alternation. In addition, Dahalo, a language spoken in Kenya, has a lenited allophone of /d̠/ that is transcribed as [ð̠] and has been described as similar to soft d (Maddieson et al. 1993).

The parallels between the Spanish narrative and Danish soft d are hard to ignore. As with Spanish, the traditional view of this sound is that it is a stop lenited into a fricative. However, more contemporary descriptions of this sound have suggested that the sound may actually be closer to an approximant, which is similar to the research trajectory in Spanish lenition studies. We feel that this is evidence to support that soft d might be an approximant.

1.3. CURRENT PAPER. The current paper focuses on two main questions: (1) is soft d a voiced fricative as it is typically transcribed and (2) if it is not a fricative, should it be transcribed this way. To the first question, this paper outlines a preliminary acoustic measurement of the harmonics-to-noise ratio, a measure of harmonicity, and how it compares to various types of segments in Danish. We hypothesized that if the soft d is actually more approximant-like than fricative-like, we would see higher harmonicity in this segment than in fricatives. To the second question, this paper will relate the acoustic characteristics of this sound and describe issues with the current practice of its transcription and offer a possible way to approach this problem.

2. Methods. 2.1. MATERIALS. A preliminary look at the spectral characteristics of soft d in one speaker's speech revealed weak formant structure within the sound and an absence of the hallmark spectral "fuzziness" of in higher frequencies that is typically seen with fricatives (see Figure 1). The weak formant structure is indicative of approximants and semi-vowels, corrobo-

rating previous descriptions by Grønnum and Basbøll[1]. This led us to decide to perform an acoustic analysis of soft d to investigate its manner of articulation.

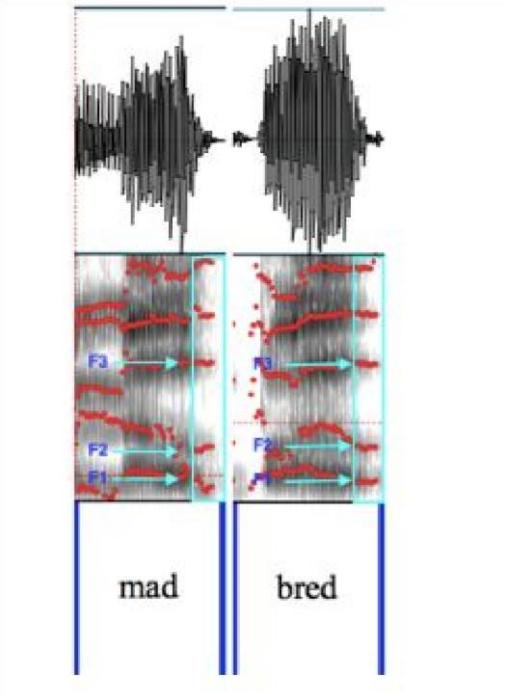

Figure 1. Spectrograms of /mɛð/ and /bʁɛð/

An acoustic analysis was carried out on recordings taken from DanPASS (Grønnum, 2016), a corpus of spontaneous Danish speech that has been phonetically and phonologically annotated. For this analysis, tokens were taken from six speakers (one female, five male); all speakers were from the Copenhagen area of Denmark and spoke Standard Danish (*rigsdansk*). Four categories of tokens (n=200) were taken: (1) voiced fricatives (some realizations of /v/, /ʁ/, and /ɣ/) (2) approximants (/j/, /l/, some realizations of /v/ and /ɣ/), (3) soft d, and (4) vowels. These categories were chosen as they represent a gradient of periodicity in which we hoped to place soft d.

As the materials in the DanPASS are heavily annotated, tokens were chosen based upon if they were annotated as the segment of interest and if these spectral characteristics matched the annotation. For example, tokens annotated as voiced but lacking spectral indications of voicing (e.g., a voice bar) were not included in the voiced fricative category. Similarly, if a segment labelled as a fricative had no obvious frication in the spectrogram, it was excluded from the voiced fricative category.

2.2. MEASUREMENT AND ANALYSIS. For each class of token, the harmonics-to-noise ratio (HNR) waseasured using Praat (Boersma & Weenink 2018). This is a measurement of the periodicity of a sound, expressed in dB (Styler 2013); a higher HNR is indicative of a more periodic sound. For this reason, voiced fricatives have lower HNR measures than approximants and vowels. Fricatives were measured from the start of turbulent energy on the waveform to the vocalization of the following vowel. Vowels were measured from the beginning of periodic

[1] Descriptions taken from their respective transcription practices.

voicing and formant structure to the cessation of these. We used formant transitions to distinguish the boundaries between vowels and approximants. The HNR measurement was taken for the entire duration of the segment.

HNR measurements were averaged across speakers and tokens for each category and two-sample t-tests were carried out to investigate the statistical significance of between-group differences. We chose this method of statistical analysis in order to tell us if there were significant differences in the HNR between soft d and the other categories.

3. Results. Soft d (n=50, $\bar{x}$ = 13.9 dB) was shown to have a significantly higher ($p<0.01$) HNR than voiced fricatives (n=50, $\bar{x}$ = 6.93 dB). It was also shown to be significantly ($p=0.011$) higher than approximants (n=50, $\bar{x}$ = 9.95 dB). However, soft d did not exhibit a significant ($p=0.76$) difference from the vowel (n=50, $\bar{x}$ = 14.14 dB) category. These differences can be seen in Figure 2.

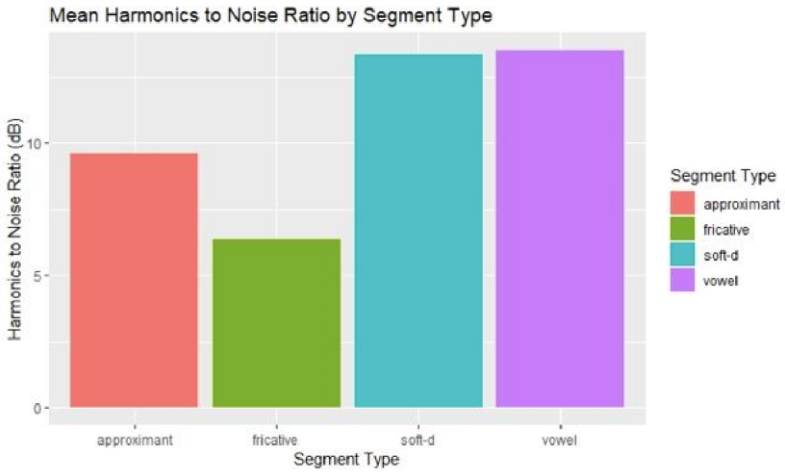

Figure 2. Average HNR values for each type of segment (approximant, fricative, soft d, vowel)

4. Discussion. These results show that the past descriptions of soft d as a voiced interdental fricative are indeed inaccurate based on its acoustic characteristics. Both the spectrogram and acoustic measures (HNR) show an absence of frication. In addition to showing that this sound is not a voiced fricative, as it is often called, this data also provide some information about its articulation. While we can not necessarily use a measure like HNR to explain the place of articulation of the sound, we can use it to describe the likely manner. It was hypothesized that if the sound was not a voiced fricative but rather something closer to an approximant or semi-vowel, this would be reflected in the HNR, a measure of periodicity, and approximants and vowels would have a higher value. The HNR value of soft d was significantly ($p<0.01$) higher than voiced fricatives and approximants, showing that these sounds are more periodic than either of these types; the values had a slightly lower average than vowels, but were not significantly different, indicating that their periodicity is more in line with these. As stated before, these three categories (voiced fricatives, approximants, vowels) were meant to create a gradient of periodicity, and soft d has been placed on this between approximants and vowels. These data corroborate to a certain extent the descriptions offered by Haberland (1994) that this sound is a semi-vowel or by Basbøll (2005) that it is an approximant.

Soft d's vowel-like periodicity indicates that perhaps it is undergoing vocalization. Approximants like /l/ (Lin et al. 2011) and /r/ (Ellis et al. 2006) are commonly vocalized cross-linguistically; it is plausible that soft d lenited into an approximant that is now undergoing vocalization. According to this explanation, diachronically soft d would have started as a stop, then lenited sequentially into a fricative, approximant, and now something that is more vowel-like. This fits with Danish's overall patterns of lenition and vowel reduction.

Given that the sound has been shown to not be a voiced fricative, these data reinforce our earlier assertion that /ð/ is inappropriate to use in transcriptions of Danish. We would suggest that Danish linguists choose one of two options moving forward in transcription: (a) finding a more accurate symbol that can be adjusted via diacritics to provide an accurate depiction, or, and perhaps more controversially, (b) using an entirely new symbol once the precise articulation of this sound has been found and described. One of the self-proclaimed goals of the IPA is to be able to transcribe narrow phonetic detail (International Phonetic Association 1999), phoneticians must strive to provide accurate and reliable transcriptions. Therefore, as linguists we must reevaluate the use of /ð/ for soft d.

As with any study, this is not without limitations. We analyzed only 200 tokens overall, and we grouped segments together into large categories in order to compare periodicity on a scale. Future work will involve larger sample sizes, as provided by the DanPASS corpus as well as spontaneous speech. Additionally, we will include more fine-grained categorical distinctions to provide a more precise and robust comparison of soft d to other segments. Additionally, we will investigate variation within different realizations of soft d, such as syllabic soft d and when stød is on a syllable with a soft d. The next step of this project is to obtain articulatory data in order to more precisely determine the place and manner of articulation of soft d. We are considering conducting ultrasound and palatography studies to begin this investigation. With these data, we hope to propose a more accurate way to transcribe soft d.

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